THE UNIVERSITY OF MANITOBA

The crustacean zooplankton communities of three prairie lakes subject to varying degrees of anoxia

by

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A Thesis

Submitted to the Faculty of Graduate Studies

in partial fulfillment of the requirements for the degree

of Master of Science

Department of Zoology

Winnipeg, Manitoba

June 1981

THE CRUSTACEAN ZOOPLANKTON COMMUNITIES OF THREE PRAIRIE LAKES SUBJECT TO VARYING DEGREES OF ANOXIA

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ABSTRACT

The crustacean zooplankton communities in three small prairie lakes subject to varying degrees of anoxia were studied for 14 months from February 1976 to April 1977. Ten or twelve samples were collected with a tube in both the deep and shallow zones of each lake once weekly during summer, biweekly in spring and fall and monthly during winter.

Local terrain was important to lake trophy and stratification. Physical and chemical observations indicated that shallow hypertrophic Lake 885 periodically stratified, exhibited winter and summer anoxia and had extreme nutrient and algal biomass levels. Shallow, meso-eutrophic Lake 255 was holomictic, displayed winter anoxia, and had lowest nutrient and phytoplankton amounts. Deeper, eutrophic Lake 019, stratified through summer, was not completely exhausted of oxygen and contained intermediate nutrient and algal concentrations. Dense populations of planktivorous fish *Pimephales promelas* and *Culaea inconstans* occurred in Lake 019 while *Salmo gairdneri* were stocked in Lakes 255 and 885.

Zooplankton community abundance and biomass, ranging on a mean annual basis from 124.7 to 289.9 ind L^{-1} and 1.9 to 10.3 mg wet weight L^{-1} respectively were governed by lake productivity and morphometry. Biomass in Lake 019 was also influenced by intense planktivory. A total of 25 species were identified, of which 10, *Cyclops bicuspidatus thomasi*, *Cyclops vernalis*, *Eucyclops agilis*, *Macrocyclops albidus*, *Diaptomus siciloides*, *Diaptomus leptopus*, *Daphnia schoedleri*, *Daphnia rosea*, *Daphnia parvula* and *Bosmina longirostris* were common to all three lakes. The number of species, highest in Lake 255 with 21 and lowest in Lake 885 with 15, was inversely related to trophy. More eulittoral species in Lake 255 were associated with extensive macrophyte development. Numerically, cyclopoids were most important in Lakes 885 and 255 while calanoids and cladocerans were most abundant in Lake 019, these trends being related to the frequency and severity of anoxia. Observed differences in the horizontal distribution of community and species abundance were associated with macrophytes, fish predation and morphology.

Seasonal community development in Lake 019 was basically monacmic with a mid summer pulse. Although diacmic patterns were observed in both Lake 885 and 255, in the former lake, spring densities were triple those of fall, the two pulses separated by a strong depression in late August. Lake 255 exhibited more equitable spring and fall pulses and a mid summer minimum. Highest community abundance during winter occurred in Lake 019. These variations were related to lake trophy, temperature, dissolved oxygen, nutrients, phytoplankton and predation.

Significant differences were observed in the seasonal dynamics of C. b. thomasi, D. siciloides and D. schoedleri. Instar analysis revealed spring emergence of C. b. thomasi from winter diapause only in Lakes 885 and 255. In Lake 019, C. b. thomasi survived through the winter carrying on reproduction. No evidence for summer diapause of this species was found in all three lakes. Spring C. b. thomasi densities were related to the severity of oxygen depletion during the preceeding winter and the intensity of invertebrate predation. Summer anoxia did not affect C. b. thomasi copepodids but was apparently fatal to nauplii.

D. schoedleri's presence only in Lakes 885 and 255 reflected reduced planktivory in winterkilled lakes. Delayed seasonal development of D. schoedleri in Lake 885 suggested possible predation by abundant C. b. thomasi. High variation in abundance and polycyclic ephippial production by D. schoedleri in Lake 885 reflected the omnipresent threat of Cyanophyte bloom

collapse. Summer anoxia severely impacted all stages of D. schoedleri.

While large quantities of resting eggs were produced by D. siciloides in winterkilled Lake 255, considerably fewer eggs were carried by females surviving winter in oxygenated Lake 019.

Relatively small differences in lake trophy and morphology appeared to effect considerable differences in oxygen conditions and seasonal crustacean plankton community composition and dynamics.

DEDICATED TO MY CHILDREN

MATTHEW
AND
KERRI

ACKNOWLEDGEMENTS

The author is most sincerely grateful for the patience, guidance and support genuinely extended by two gentlemen, Drs. F. J. Ward and K. Patalas. Their keen interest and invaluable advice provided encouragement and inspiration throughout this learning experience. I also wish to thank Dr. J. Eales for his assistance during the sabbatical of Dr. Ward.

Without the help of Mr. G. Curry, difficult winter sampling would not have proceeded as smoothly. The co-operation and comradary of V. Srisuwantach, P. Tavarutmaneegal and J. Boonsom, visiting from Thailand, enriched and enlightened field and laboratory activities. The participation of Dr. J. Mathias during a macrophyte vegetation survey was greatly appreciated. The efforts of Drs. J. Barica and B. Ayles , J. Lark, J. Gibson and C. Eccles insured a well organized Erickson field camp where many enjoyable moments were spent.

Other members of the Freshwater Institute also deserve recognition and thanks. I. Davies provided a statistical program to evaluate population estimates. H. Kling kindly offered her unpublished data of algal biomass. D. Laroque and C. Vitt perservered to type the large tables and original text. L. Taite, D. Taite and L. Blouw prepared final versions of many figures. And to numerous colleagues who sacrificed coffee and lunch periods to listen, criticize and clarify my ideas, I hope to repay the thoughtfulness.

Finally, I am deeply indebted to my children, family and friends who willingly offered their love and understanding so that I might accomplish this task.

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INTRODUCTION

The understanding of crustacean zooplankton ecology in western Canada has grown appreciably over the past 50 years. To a large extent, the evolution of this knowledge was governed by the size, remoteness and the economic development of this region. Early studies by Baikov (1930, 1934), Rawson (1947, 1960) and Reed (1964) among others concentrated primarily on documenting fundamental limnological data from some of the more prominent lakes in the west.

As investigations continued, post glacial dispersion patterns of crustacean species were also considered. Studies by Carl (1940) and Anderson (1974) on montaine lakes in British Columbia, the saline lakes of Saskatchewan by Rawson and Moore (1944) and Moore (1952), on North American daphnids by Brooks (1957), large North American lakes by Patalas (1975), the Yukon lakes by Archibald (1977) have contributed towards our understanding of this process.

To complement this fundamental research, more effort is now being directed towards examining the temporal and spatial variability of zooplankton communities as well as the environmental and biotic factors governing plankton dynamics. Because of technical difficulties involved in remote sampling, the earlier works were usually restricted to a single sampling period in mid-summer or to one limnetic station. In the past, this approach was adequate for classifying lacustrine productivity and trophic status (Larkin and Northcote 1958, Rawson 1961). Today, when the environmental impacts of toxins, petroleums, acids, radioactive wastes and other contaminants associated with cultural eutrophication need to be accurately assessed, a clear idea of "natural" community and population fluctuations is an important prerequisite. Likewise, the horizontal variation of plankton distributions within lakes needs quantitative refinement. Information is available for larger eastern Canadian lakes (Langford 1938; Davis 1966; Rigler and Langford 1967; Schindler and Noven 1971; Patalas 1969, 1971, 1972; Davis 1973; Watson and Carpenter 1974; Clark and Carter 1974; McNaught and Buzzard 1974) but few studies have been undertaken in the west (Bajkov 1929; Hammer and Sawchyn 1968; Anderson 1970; Donald 1971; Lei and Clifford 1974; Herzig et al. 1980). Although comparison with other data is instructive, the high degree of crustacean community variability recorded throughout the literature (Hutchinson 1967) impresses the need of further regional sampling. As Schindler (1978) points out, more complete data are still needed for many areas.

Prairie pothole lakes are characteristically shallow, nutrient rich and often covered with aesthetically unappealing algal scums, perhaps the reason for their lack of attention. As a result of their physicochemical properties, many are impacted by catastrophic "summer or winterkills", periods of low (< 1.0 mg O_2 L^{-1}) oxygen concentration which are often fatal to resident fish but allow for development of extremely dense invertebrate populations. This invertebrate resource currently supports rainbow trout aquaculture in the Erickson-Elphinstone area of western Manitoba. Several lakes in the district, because of their relatively larger size, do not exhibit periods of complete anoxia and consequently support perrenial fish populations. This combination of "kill and non-kill" lakes provided a unique opportunity to examine the effects of anoxia on crustacean zooplankton development as well as to compare zooplankton community structure, seasonal dynamics and trophic interrelationships within three lakes 019, 255, and 885. Differences between the plankton of deeper, central and shallower, nearshore zones of each lake were also considered. Winter sampling formed a significant part of the study since data on planktonic growth during the ice cover period are relatively scarce.

This research was conducted as one part of a joint program involving the efforts of V. Srisuwantach (1978) - nutrients and phytoplankton, P. Tavarutmaneegul (1978) - rainbow trout production and J. Boonsom, zooplankton-fish interactions. The study, supported by the Freshwater Institute, provided for a comprehensive analysis of the prairie pothole ecosystem. Perhaps it can be considered a forerunner of the cooperative thesis concept advocated by Vallentyne (1974).

THE LAKES

Lakes 885, 255 and 019 are located in west central Manitoba near the town of Erickson, positioned at 50°30'N and 99°55'W, approximately 330 km northwest of Winnipeg (Fig. 1). The study area lies on the Manitoba Escarpment which rises between 460 and 760 meters above the lowland plains of central Manitoba at 450 m a.s.l. Morrainal deposits characterizing the region were remnants of the final, Wisconsinan stage of Pleistocene glaciation. With the retreat of Lake Agassiz, hundreds of small, shallow ponds and lakes remained which ultimately became domestic and livestock watering sources for many farms developing in the area. Lake 019 currently receives drainage from a barnyard and farmhouse on its northern shore while lake 885 is situated on an abandoned farmstead (Figs. 2a,c). Both lakes are largely surrounded by trees and are adjoined by grainfields of predominantly grey wooded or fertile black soils. Lake 255 (Fig. 2b), situated between a railroad track and a provincial highway, is comparatively removed from direct agricultural influence although a cultivated field exists a short distance to the east.

Figure 1. The location of Lakes 019, 255 and 885 in the Erickson-Elphinstone, Manitoba study area.

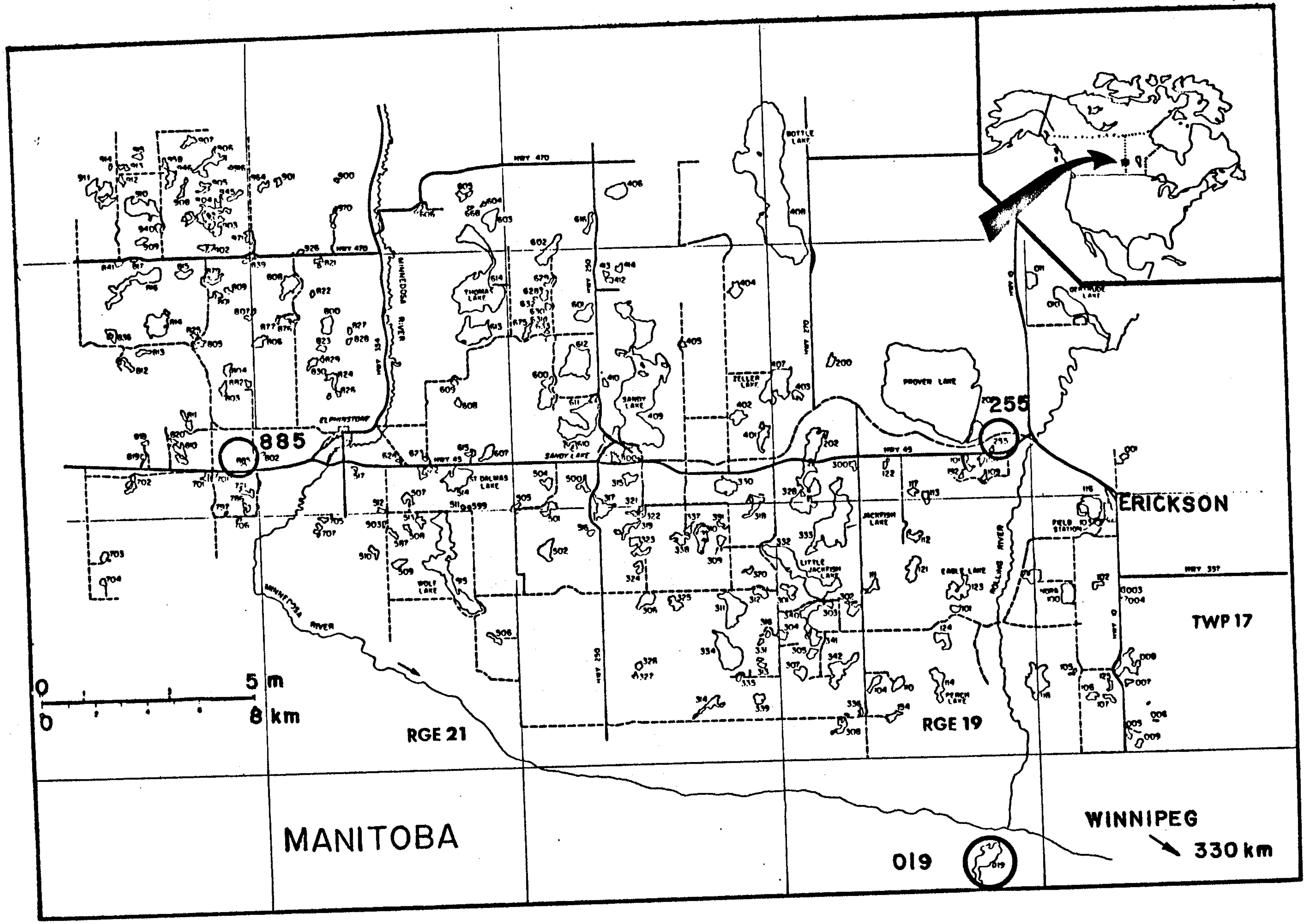
885
255
ERICKSON
TWP 17
RGE 21
RGE 19
MANITOBA
019
WINNIPEG
330 km
0
5 m
0
8 km
HWY 45
HWY 470
HWY 357
PROVEN LAKE
SANDY LAKE
BOTTLE LAKE
MINNEDOSA RIVER
ROLLING RIVER
LITTLE JACKFISH LAKE
JACKFISH LAKE
EAGLE LAKE
WOLF LAKE
PEACH LAKE

Figure 2a. Bathymetric map of Lake 019 (contours in meters) showing the distribution of shallow(s) and deep (D) zone sampling stations each with a pair of sub-sampling sites (o and ● or □ and ■). Subsamples from similarly designated sites within each zone combined, resulting in two composite samples from each zone. Extent of emergent macrophytes...... and borderline of trees and cultivated fields----- also indicated. Trees, farm buildings and roadways approximately to scale.